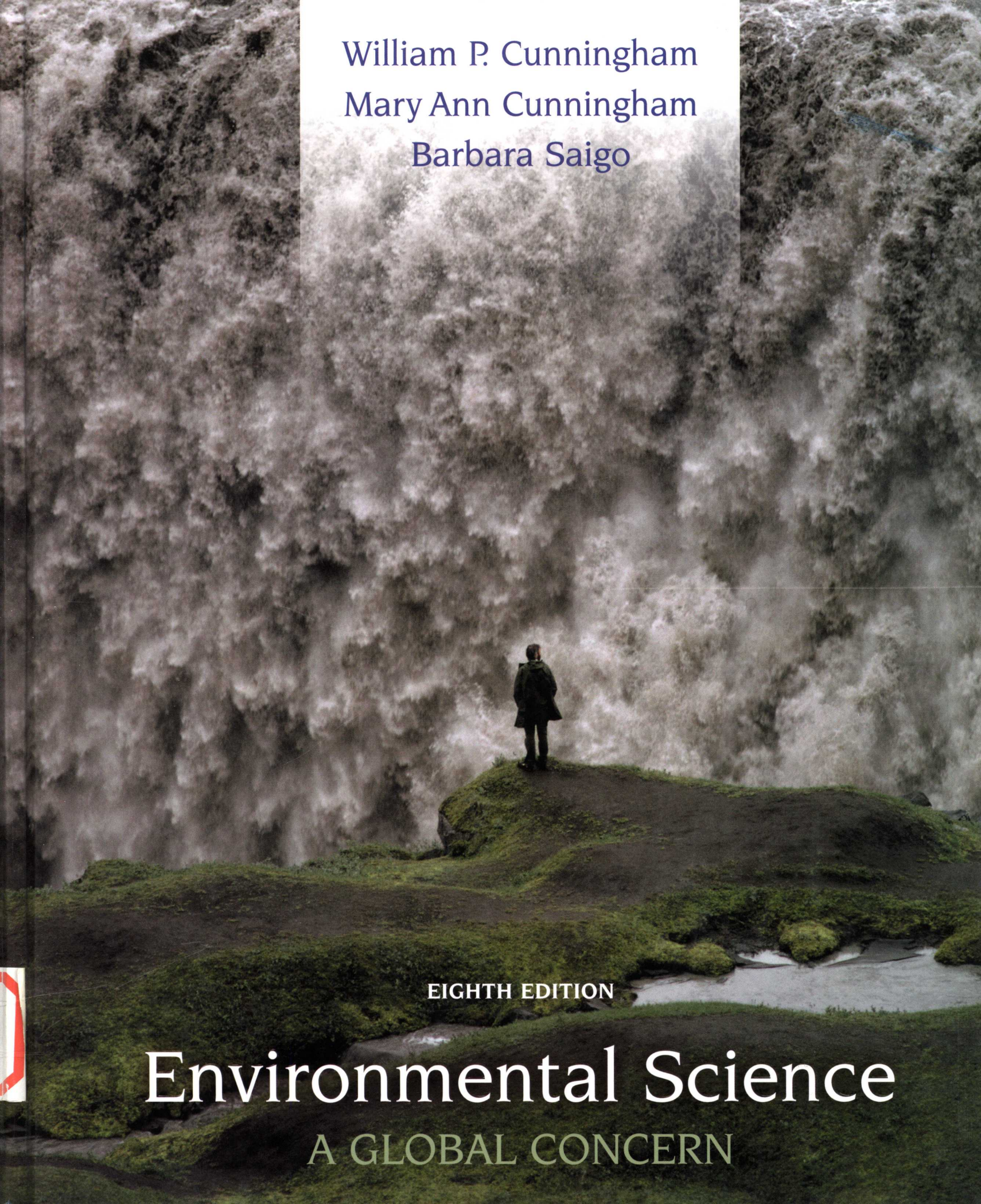
William P. Cunningham
Mary Ann Cunningham
Barbara Saigo



EIGHTH EDITION

Environmental Science

A GLOBAL CONCERN

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William P. Cunningham
University of Minnesota

MaryAnn Cunningham
Vassar College

Barbara Woodworth Saigo

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ENVIRONMENTAL SCIENCE: A GLOBAL CONCERN
EIGHTH EDITION

2 3 4 5 6 7 8 9 0 / 0 9 8 7 6 5

ISBN 0-07-243956-4

Publisher: *Margaret J. Kemp*
Senior developmental editor: *Kathleen R. Loewenberg*
Executive marketing manager: *Lisa L. Gottschalk*
Lead project manager: *Joyce M. Berendes*
Lead production supervisor: *Sandy Ludovissy*
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Cover/interior designer: *Jamie E. O'Neal*
Cover image: *"Tiny Figure" by Dettifoss/Bryan & Cherry Alexander Photography*
Senior photo research coordinator: *Lori Hancock*
Photo research: *Connie Mueller*
Supplement producer: *Brenda A. Ernzen*
Compositor: *Precision Graphics*
Typeface: *10/12 Times Roman*
Printer: *Quebecor World Dubuque Inc.*

Interior design image credits:
Title Page: *Digital Vision, PhotoDisc;* Preface Header: *PhotoDisc, Digital Vision, Artville;* Brief Contents Header: *Corbis, Artville;* Contents Header: *Corbis, Digital Vision;* Glossary/Credits/Index Headers: *Corbis, Digital Vision;* What Do You Think? Icon: *Getty Images;* Exploring Science Icon: *Getty Images, Corbis;* Case Study Icon: *Artville;* What Can You Do? Icon: *Getty Images;* Tables: *Corbis;* Key Concepts: *Corbis*

Library of Congress Cataloging-in-Publication Data

Cunningham, William P.
Environmental science : a global concern. — 8th ed. / William P. Cunningham, Mary Ann Cunningham, Barbara Woodworth Saigo.
p. cm.
Includes index.
ISBN 0-07-243956-4
1. Environmental sciences. I. Cunningham, Mary Ann. II. Saigo, Barbara Woodworth. III. Title.

GE105.C86 2005
363.7—dc22

2003025301
CIP

www.mhhe.com

EIGHTH EDITION

Environmental Science

A GLOBAL CONCERN

PREFACE

We face a rising epidemic of global environmental problems: global warming, diminishing biodiversity, growing shortages in freshwater supplies, long range transport of air pollutants and accumulation of persistent organic compounds in food webs, to mention just a few. To combat these problems and to find ways to prevent others from occurring, we need an environmentally-informed citizenry. The purpose of this book is to provide an interesting, accessible introduction to environmental science for students from a variety of backgrounds. Combining a broad, interdisciplinary approach that includes both natural sciences and human dimensions of environmental issues, this book integrates information from many different areas in a way that is accessible and useful to students from any field of study.

AUDIENCE

This book is intended for use in a one- or two-semester course in environmental science, human ecology, or environmental studies at the college or advanced placement high school level. Because most students who will use this book are freshmen or sophomore non-science majors, we have tried to make the text readable and accessible without technical jargon or a presumption of prior science background. At the same time, enough data and depth are presented to make this book suitable for many upper-division classes and a valuable resource for students who will keep it in their personal libraries after their formal studies are completed.

SUSTAINABILITY

An overarching theme in this book is sustainability: can we find ways to meet our present needs without compromising the ability of future generations to meet their own needs. Can we live on renewable energy sources and the surplus produced by biogeochemical cycles without damaging the productive capacity of our environment? The concepts of inherent values, ethical rights, stewardship, and equity between generations and between people living under different conditions now all play important roles in our consideration of how natural resources should be managed. Consequently, ethics, philosophy and environmental worldviews are among the first topics we discuss in this book.

"This text is excellent as it provides a balanced view of renewable energy sources, taking into account both the advantages and disadvantages of the available technologies."

Lawrence Roberge
Goodwin College

CRITICAL THINKING

Critical thinking is another central theme in this book. Environmental science is a complex field, one in which a large number of special interests, contradictory data, and conflicting interpretations battle for our attention. How can we decide what to believe when apparently equally eminent experts hold diametrically opposed opinions on controversial topics? Perhaps the most valuable skill any student can gain from the study of environmental science is the ability to think purposively, analytically, and clearly about evidence. To understand the complexity and conflicting interpretations of environmental problems, students need a number of skills. They need to be able to identify and evaluate biases, recognize and assess assumptions, and understand conceptual frameworks. They must also learn to acknowledge and clarify uncertainties, equivocations, and contradictions in arguments. Reaching satisfactory conclusions about environmental dilemmas isn't just a matter of logic and rationality; we also need open-mindedness, skepticism, independence, and an ability to empathize with others. We discuss these skills in the introductory chapter of this book and then model their application in boxed readings, case studies, and questions at the ends of each chapter.

"Objectivity, readability, and visual presentations all combine to make this text stand out from all of the others out there. The authors' thoroughness and objective treatment of the topics are genuine strengths of this textbook."

Ned Knight
Linfield College

BALANCED VIEW

In every edition of this textbook, we have tried to pull together and summarize the most important current environmental information, and to explain the context and significance of scientific evidence. There's a temptation, in discussing environmental conditions to focus on extremes. While acknowledging problems, we also are careful to describe good news, progress towards sustainability, and the many ways individuals can make positive contributions toward environmental protection. Because science is always conditional, and there can be many ways to interpret data, we also present a balanced view that recognizes uncertainties and conflicting interpretations. At the same time, we stress that scientific consensus does emerge on major issues. We feel it is essential that students understand the need for differing interpretations of evidence and also recognize the value of general agreement among scholars.

"The voice of the Cunningham text is more optimistic than the book we are currently using."

Susan Brydon Golz
Rockland Community College

We hope you will find this book a valuable source of information about our global environment, as well as an inspiration for solutions to the dilemmas we face. Everyone has a role to play in this endeavor. Whether as students, educators, researchers, activists, or consumers, each of us can find ways to contribute in solving our common problems.

GLOBAL CONCERN

We live in an increasingly interconnected world. An awareness of international events, population trends, health conditions, and environmental quality are essential for educated citizens. The coal burned in China, the nuclear waste dumped in the ocean by Russia, or the pesticides used on farms in Central America affects all of us. This text has set the standard in the market for incorporating a worldview of environmental issues into each chapter with discussions in the text, photos, examples used, boxed readings, and data.

"Seldom have I seen such a good, succinct explanation of historical trends in world temperature means and why Milankovitch cycles occur."

David A. Francko
Miami University (Ohio)

UNIQUE "HOW TO STUDY" CHAPTER

Our first chapter provides information that most students need but that is rarely discussed in introductory texts: how to study, how to prepare for tests, critical thinking, concept maps, and why environmental science is exciting and important. These topics are presented in the beginning of the book so students can begin to use them immediately. This is the kind of information that most of us cover in the first lecture of a class. No other textbook goes into the depth on the fundamentals of critical thinking theory and application found here.

"What a novel idea! Many of our students come into the course with a circumscribed background in science, and this section answers many questions that are foremost in their minds. I believe that this chapter does a wonderful job of opening the idea of active self-learners to them and importantly describes the techniques needed to make this transition."

Glenn Wehner
Truman State University

NEW TO THIS EDITION

The eighth edition has undergone a major revision and reorganization reflecting both the wealth of new information available and valuable suggestions for improvement by a large number of reviewers who have been kind enough to read the text carefully and give us their detailed comments. Among these changes are:

- Updated art program with 129 new photographs and over 100 new or revised pieces of line art, including 50 new, realistic, 3D drawings.

"The photographs are good and generally have short and to-the-point captions. There are a number of very good illustrations of which I have not seen this type of before in any other text."

Patricia Smith
Valencia Community College

- New Key Concepts boxes to help students keep track of major points.
- New Exploring Science boxes to emphasize important scientific questions and help students understand how science works.
- New large fold-out piece featuring full-color physiographic and political world maps.
- New bulleted list format for Chapter Summaries so that students will recognize major issues more clearly.
- Updated graphs and tables with new data or better presentations.
- Revised Chapter Objectives and Questions for Review and Discussion to reflect new and revised material. To help students study effectively, all these elements follow the chapter organization more closely than before.
- New brief list of Selected Readings in each chapter to suggest some especially valuable sources for further study. We also have a much more extensive reading list on the Online Learning Center with roughly 100 citations from recent literature per chapter.

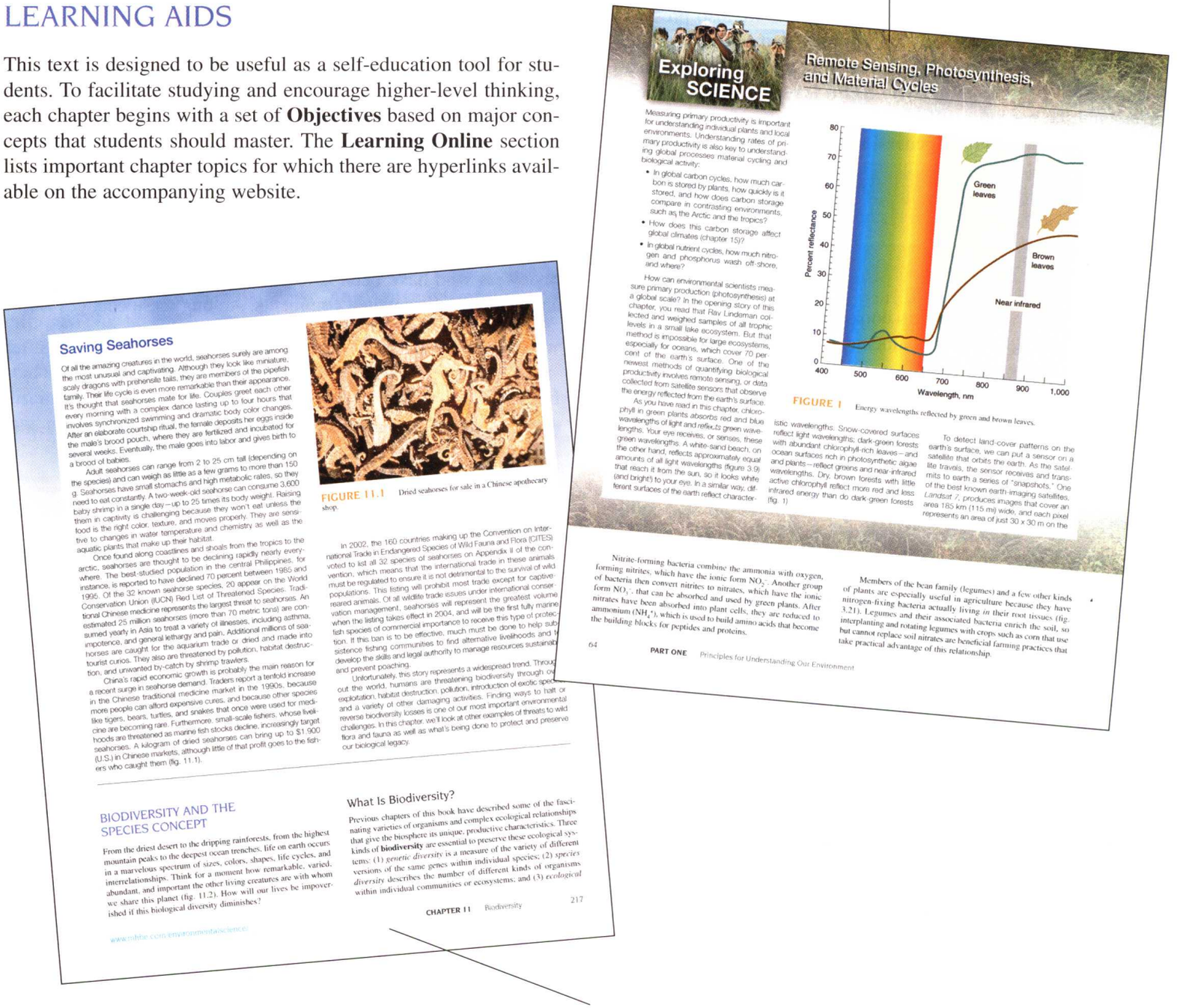
- Moved chapters 8 (Ecological Economics) and 10 (Environmental Policy and Law) at the suggestion of several reviewers, from the middle to the end of the book. These chapters can now serve as a capstone for previous discussions.

Visit www.mhhe.com/environmentalscience and click on this text's title to access a detailed list of changes for each chapter.

LEARNING AIDS

This text is designed to be useful as a self-education tool for students. To facilitate studying and encourage higher-level thinking, each chapter begins with a set of **Objectives** based on major concepts that students should master. The **Learning Online** section lists important chapter topics for which there are hyperlinks available on the accompanying website.

New **"Exploring Science"** boxes focus on the science behind the story. **Case Studies, "What Do You Think?"** essays, many with **"Ethical Considerations"** attached, also give students real-life examples to evaluate. All of these boxed readings are carefully planned to build upon chapter content and encourage students to practice critical thinking skills and formulate reasoned opinions.



Saving Seahorses

Of all the amazing creatures in the world, seahorses surely are among the most unusual and captivating. Although they look like miniature, scaly dragons with prehensile tails, they are members of the pipefish family. Their life cycle is even more remarkable than their appearance. It's thought that seahorses mate for life. Couples greet each other every morning with a complex dance lasting up to four hours that involves synchronized swimming and dramatic body color changes. After an elaborate courtship ritual, the female deposits her eggs inside the male's brood pouch, where they are fertilized and incubated for several weeks. Eventually, the male goes into labor and gives birth to a brood of babies.

Adult seahorses can range from 2 to 25 cm tall (depending on the species) and can weigh as little as a few grams to more than 150 g. Seahorses have small stomachs and high metabolic rates, so they need to eat constantly. A two-week-old seahorse can consume 3,600 baby shrimp in a single day—up to 25 times its body weight. Raising them in captivity is challenging because they won't eat unless the food is the right color, texture, and moves properly. They are sensitive to changes in water temperature and chemistry as well as the aquatic plants that make up their habitat.

Once found along coastlines and shoals from the tropics to the arctic, seahorses are thought to be declining rapidly nearly everywhere. The best-studied population in the central Philippines, for instance, is reported to have declined 70 percent between 1985 and 1995. Of the 32 known seahorse species, 20 appear on the World Conservation Union (IUCN) Red List of Threatened Species. Traditional Chinese medicine represents the largest threat to seahorses. An estimated 25 million seahorses (more than 70 metric tons) are consumed yearly in Asia to treat a variety of illnesses, including asthma, impotence, and general lethargy and pain. Additional millions of seahorses are caught for the aquarium trade or dried and made into tourist curios. They also are threatened by pollution, habitat destruction, and unwanted by-catch by shrimp trawlers.

China's rapid economic growth is probably the main reason for a recent surge in seahorse demand. Traders report a tenfold increase in the Chinese traditional medicine market in the 1990s, because more people can afford expensive cures, and because other species like tigers, bears, turtles, and snakes that once were used for medicine are becoming rare. Furthermore, small-scale fishers, whose livelihoods are threatened as marine fish stocks decline, increasingly target seahorses. A kilogram of dried seahorses can bring up to $1,900 (U.S.) in Chinese markets, although little of that profit goes to the fishers who caught them (fig. 11.1).

FIGURE 11.1 Dried seahorses for sale in a Chinese apothecary shop.

In 2002, the 160 countries making up the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) voted to list all 32 species of seahorses on Appendix II of the convention, which means that the international trade in these animals must be regulated to ensure it is not detrimental to the survival of wild populations. This listing will prohibit most trade except for captive-reared animals. Of all wildlife trade issues under international conservation management, seahorses will represent the greatest volume when the listing takes effect in 2004, and will be the first fully marine fish species of commercial importance to receive this type of protection. If this ban is to be effective, much must be done to help subsistence fishing communities to find alternative livelihoods and to develop the skills and legal authority to manage resources sustainably and prevent poaching.

Unfortunately, this story represents a widespread trend. Throughout the world, humans are threatening biodiversity through overexploitation, habitat destruction, pollution, introduction of exotic species, and a variety of other damaging activities. Finding ways to halt or reverse biodiversity losses is one of our most important environmental challenges. In this chapter, we'll look at other examples of threats to wild flora and fauna as well as what's being done to protect and preserve our biological legacy.

BIODIVERSITY AND THE SPECIES CONCEPT

From the driest desert to the dripping rainforests, from the highest mountain peaks to the deepest ocean trenches, life on earth occurs in a marvelous spectrum of sizes, colors, shapes, life cycles, and interrelationships. Think for a moment how remarkable, varied, abundant, and important the other living creatures are with whom we share this planet (fig. 11.2). How will our lives be impoverished if this biological diversity diminishes?

What Is Biodiversity?

Previous chapters of this book have described some of the fascinating varieties of organisms and complex ecological relationships that give the biosphere its unique, productive characteristics. Three kinds of **biodiversity** are essential to preserve these ecological systems: (1) *genetic diversity* is a measure of the variety of different versions of the same genes within individual species; (2) *species diversity* describes the number of different kinds of organisms within individual communities or ecosystems; and (3) *ecological*

CHAPTER 11 Biodiversity 217

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Exploring SCIENCE

Remote Sensing, Photosynthesis, and Material Cycles

Measuring primary productivity is important for understanding individual plants and local environments. Understanding rates of primary productivity is also key to understanding global processes material cycling and biological activity:

- In global carbon cycles, how much carbon is stored by plants, how quickly is it stored, and how does carbon storage compare in contrasting environments, such as the Arctic and the tropics?
- How does this carbon storage affect global climates (chapter 15)?
- In global nutrient cycles, how much nitrogen and phosphorus wash off-shore, and where?

How can environmental scientists measure primary production (photosynthesis) at a global scale? In the opening story of this chapter, you read that Rav Lindeman collected and weighed samples of all trophic levels in a small lake ecosystem. But that method is impossible for large ecosystems, especially for oceans, which cover 70 percent of the earth's surface. One of the newest methods of quantifying biological productivity involves remote sensing, or data collected from satellite sensors that observe the energy reflected from the earth's surface.

As you have read in this chapter, chlorophyll in green plants *absorbs* red and blue wavelengths of light and *reflects* green wavelengths. Your eye receives, or senses, these green wavelengths. A white-sand beach, on the other hand, reflects approximately equal amounts of all light wavelengths (figure 3.9) that reach it from the sun, so it looks white (and bright) to your eye. In a similar way, different surfaces of the earth reflect characteristic wavelengths. Snow-covered surfaces reflect light wavelengths; dark-green forests with abundant chlorophyll-rich leaves—and ocean surfaces rich in photosynthetic algae and plants—reflect greens and near-infrared wavelengths. Dry, brown forests with little active chlorophyll reflect more red and less infrared energy than do dark-green forests (fig. 1)

FIGURE 1 Energy wavelengths reflected by green and brown leaves.

To detect land-cover patterns on the earth's surface, we can put a sensor on a satellite that orbits the earth. As the satellite travels, the sensor receives and transmits to earth a series of "snapshots." One of the best known earth-imaging satellites, *Landsat 7*, produces images that cover an area 185 km (115 mi) wide, and each pixel represents an area of just 30 x 30 m on the

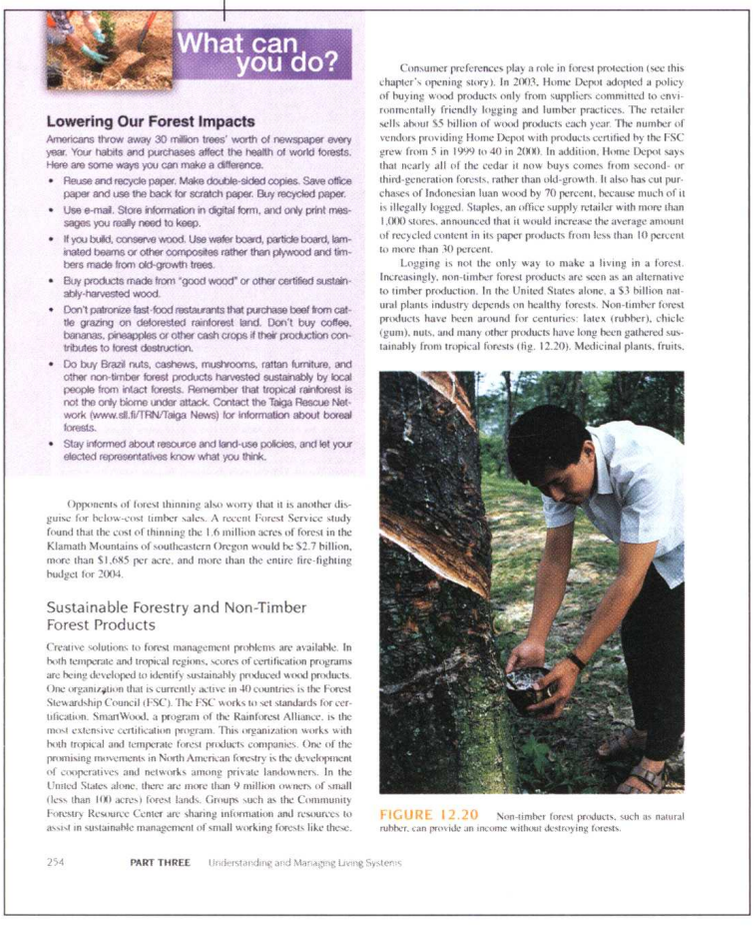
Nitrite-forming bacteria combine the ammonia with oxygen, forming nitrites, which have the ionic form NO_2^-. Another group of bacteria then convert nitrites to nitrates, which have the ionic form NO_3^-, that can be absorbed and used by green plants. After nitrates have been absorbed into plant cells, they are reduced to ammonium (NH_4^+), which is used to build amino acids that become the building blocks for peptides and proteins.

Members of the bean family (legumes) and a few other kinds of plants are especially useful in agriculture because they have nitrogen-fixing bacteria actually living in their root tissues (fig. 3.21). Legumes and their associated bacteria enrich the soil, so interplanting and rotating legumes with crops such as corn that use but cannot replace soil nitrates are beneficial farming practices that take practical advantage of this relationship.

64 PART ONE Principles for Understanding Our Environment

A short **Opening Story,** taken from recent news events, sets the subject in context and illuminates the importance of the material to be discussed. **Key Terms,** indicated by boldface type, are defined in the context where they are first used, and are also defined in the **Glossary** for quick reference.

The **"What Can You Do?"** listings help students to learn that small, individual steps can make a real difference in affecting our environment.



What can you do?

Lowering Our Forest Impacts

Americans throw away 30 million trees' worth of newspaper every year. Your habits and purchases affect the health of world forests. Here are some ways you can make a difference.

- Reuse and recycle paper. Make double-sided copies. Save office paper and use the back for scratch paper. Buy recycled paper.
- Use e-mail. Store information in digital form, and only print messages you really need to keep.
- If you build, conserve wood. Use wafer board, particle board, laminated beams or other composites rather than plywood and timbers made from old-growth trees.
- Buy products made from "good wood" or other certified sustainably-harvested wood.
- Don't patronize fast-food restaurants that purchase beef from cattle grazing on deforested rainforest land. Don't buy coffee, bananas, pineapples or other cash crops if their production contributes to forest destruction.
- Do buy Brazil nuts, cashews, mushrooms, rattan furniture, and other non-timber forest products harvested sustainably by local people from intact forests. Remember that tropical rainforest is not the only biome under attack. Contact the Taiga Rescue Network (www.sll.fi/TRN/Taiga News) for information about boreal forests.
- Stay informed about resource and land-use policies, and let your elected representatives know what you think.

Opponents of forest thinning also worry that it is another disguise for below-cost timber sales. A recent Forest Service study found that the cost of thinning the 1.6 million acres of forest in the Klamath Mountains of southeastern Oregon would be $2.7 billion, more than $1,685 per acre, and more than the entire fire-fighting budget for 2004.

Sustainable Forestry and Non-Timber Forest Products

Creative solutions to forest management problems are available. In both temperate and tropical regions, scores of certification programs are being developed to identify sustainably produced wood products. One organization that is currently active in 40 countries is the Forest Stewardship Council (FSC). The FSC works to set standards for certification. SmartWood, a program of the Rainforest Alliance, is the most extensive certification program. This organization works with both tropical and temperate forest products companies. One of the promising movements in North American forestry is the development of cooperatives and networks among private landowners. In the United States alone, there are more than 9 million owners of small (less than 100 acres) forest lands. Groups such as the Community Forestry Resource Center are sharing information and resources to assist in sustainable management of small working forests like these.

Consumer preferences play a role in forest protection (see this chapter's opening story). In 2003, Home Depot adopted a policy of buying wood products only from suppliers committed to environmentally friendly logging and lumber practices. The retailer sells about $5 billion of wood products each year. The number of vendors providing Home Depot with products certified by the FSC grew from 5 in 1999 to 40 in 2000. In addition, Home Depot says that nearly all of the cedar it now buys comes from second- or third-generation forests, rather than old-growth. It also has cut purchases of Indonesian luan wood by 70 percent, because much of it is illegally logged. Staples, an office supply retailer with more than 1,000 stores, announced that it would increase the average amount of recycled content in its paper products from less than 10 percent to more than 30 percent.

Logging is not the only way to make a living in a forest. Increasingly, non-timber forest products are seen as an alternative to timber production. In the United States alone, a $3 billion natural plants industry depends on healthy forests. Non-timber forest products have been around for centuries: latex (rubber), chicle (gum), nuts, and many other products have long been gathered sustainably from tropical forests (fig. 12.20). Medicinal plants, fruits,

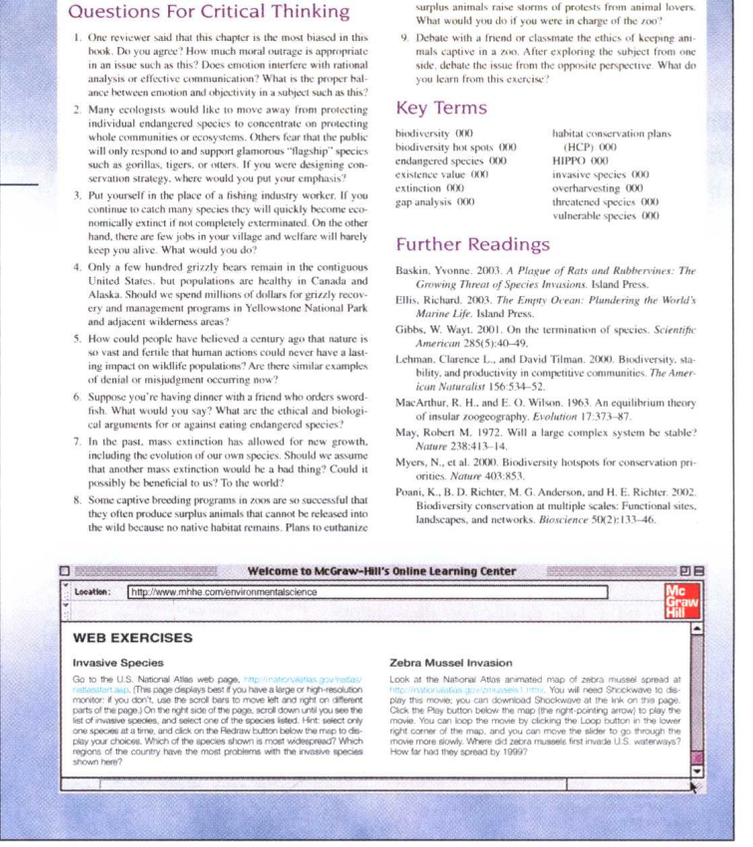
FIGURE 12.20 Non-timber forest products, such as natural rubber, can provide an income without destroying forests.

New **Three-Dimensional Art** has transformed this eighth edition and raised it to a new standard, providing students with images that are more realistic and identifiable. For example, life-like images of wolves, hares, Inuit people, and other organisms involved in the artic food web allow the students to more accurately visualize the connections between these various components.

"These are great illustrations, much improved over the common diagrammatic-flow representations used in most texts."

David I. Johnson
Michigan State University

At the end of each chapter, a bulleted **Summary** and a set of **Questions for Review** provide an opportunity for students to test their understanding of the material just covered, while **Questions for Critical Thinking** are designed to stimulate creative, analytical thinking and to serve as a springboard for class discussions. **Web Exercises** make use of current data on the Internet and ask students to perform activities such as graphing data, comparing maps, and using live GIS sources to learn about environmental issues and information sources.



Questions For Critical Thinking

1. One reviewer said that this chapter is the most biased in this book. Do you agree? How much moral outrage is appropriate in an issue such as this? Does emotion interfere with rational analysis or effective communication? What is the proper balance between emotion and objectivity in a subject such as this?
2. Many ecologists would like to move away from protecting individual endangered species to concentrate on protecting whole communities or ecosystems. Others fear that the public will only respond to and support glamorous "flagship" species such as gorillas, tigers, or otters. If you were designing conservation strategy, where would you put your emphasis?
3. Put yourself in the place of a fishing industry worker. If you continue to catch many species they will quickly become economically extinct if not completely exterminated. On the other hand, there are few jobs in your village and welfare will barely keep you alive. What would you do?
4. Only a few hundred grizzly bears remain in the contiguous United States, but populations are healthy in Canada and Alaska. Should we spend millions of dollars for grizzly recovery and management programs in Yellowstone National Park and adjacent wilderness areas?
5. How could people have believed a century ago that nature is so vast and fertile that human actions could never have a lasting impact on wildlife populations? Are there similar examples of denial or misjudgment occurring now?
6. Suppose you're having dinner with a friend who orders swordfish. What would you say? What are the ethical and biological arguments for or against eating endangered species?
7. In the past, mass extinction has allowed for new growth, including the evolution of our own species. Should we assume that another mass extinction would be a bad thing? Could it possibly be beneficial to us? To the world?
8. Some captive breeding programs in zoos are so successful that they often produce surplus animals that cannot be released into the wild because no native habitat remains. Plans to euthanize surplus animals raise storms of protests from animal lovers. What would you do if you were in charge of the zoo?
9. Debate with a friend or classmate the ethics of keeping animals captive in a zoo. After exploring the subject from one side, debate the issue from the opposite perspective. What do you learn from this exercise?

Key Terms

biodiversity 000
biodiversity hot spots 000
endangered species 000
existence value 000
extinction 000
gap analysis 000
habitat conservation plans (HCP) 000
HIPPO 000
invasive species 000
overharvesting 000
threatened species 000
vulnerable species 000

Further Readings

Baskin, Yvonne. 2003. *A Plague of Rats and Rubbervines: The Growing Threat of Species Invasions.* Island Press.

Ellis, Richard. 2003. *The Empty Ocean: Plundering the World's Marine Life.* Island Press.

Gibbs, W. Wayt. 2001. On the termination of species. *Scientific American* 285(5):40–49.

Lehman, Clarence L., and David Tilman. 2000. Biodiversity, stability, and productivity in competitive communities. *The American Naturalist* 156:534–52.

MacArthur, R. H., and E. O. Wilson. 1963. An equilibrium theory of insular zoogeography. *Evolution* 17:373–87.

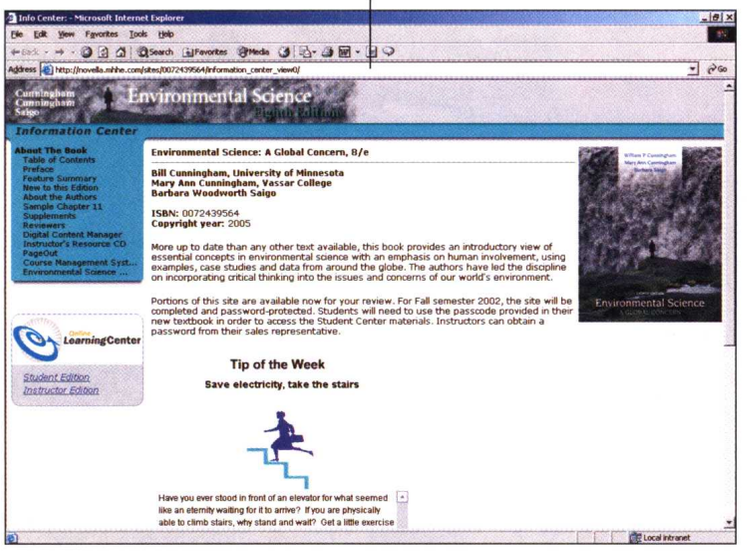
May, Robert M. 1972. Will a large complex system be stable? *Nature* 238:413–14.

Myers, N., et al. 2000. Biodiversity hotspots for conservation priorities. *Nature* 403:853.

Poani, K., B. D. Richter, M. G. Anderson, and H. E. Richter. 2002. Biodiversity conservation at multiple scales: Functional sites, landscapes, and networks. *Bioscience* 50(2):133–46.

USEFUL SUPPLEMENTS

- **Digital Content Manager (DCM) CD-ROM.** This multimedia collection of visual resources allows instructors to utilize artwork from the text in multiple formats to create customized classroom presentations, visually based tests and/or quizzes, dynamic course website content, or attractive printed support materials (see fold-out piece for more information).
- **Instructor's Testing and Resource CD-ROM.** This cross-platform CD-ROM provides a computerized test bank utilizing Brownstone Diploma@ testing software to quickly create customized exams. The user-friendly program allows instructors to search for questions by topic, format, or difficulty level; edit existing questions or add new ones; and scramble questions and answer keys for multiple versions of the same test.
- **Transparencies.** A set of 100 transparencies is available to users of the text. These acetates include key figures from the text, including new art from this edition.
- **Online Learning Center** (www.mhhe.com/ environmentalscience/). This comprehensive website offers numerous resources for both students and instructors.

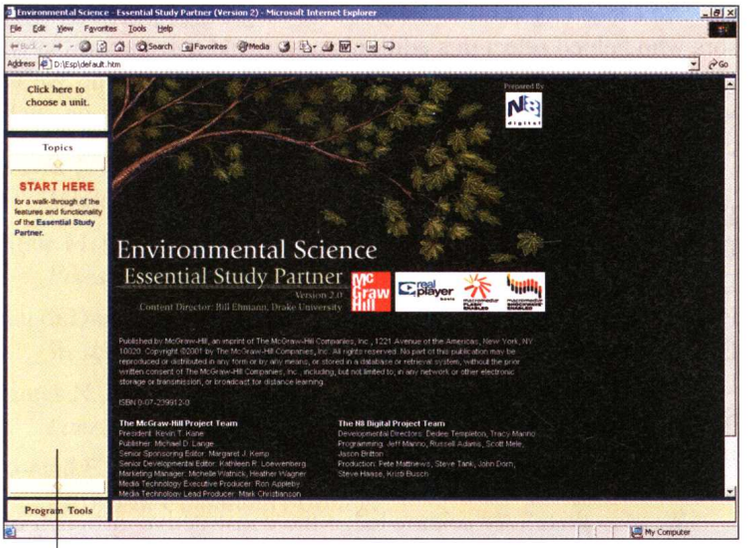


Student Resources—Everything you need in one place:

—Practice quizzing
—How to study tips
—Hyperlinks on chapter topics
—Web exercises
—Guide to electronic research
—Regional Perspectives (case studies)
—Environmental issues world map
—Key-term flashcards
—How to Contact Your Elected Officials
—Further readings
—Metric equivalents and conversion tables
—Career information
—PowerWeb's hundreds of current articles and daily news items have been integrated into each chapter on the OLC
—Access Science offers the advantage of an online, interactive encyclopedia

Instructor Resources—In addition to <u>all of the above</u>, you'll receive:

—Supplements resource chart for each chapter
—Questions for eInstruction
—Answers to web exercises
—Additional case studies
—Answers to critical thinking questions
—PageOut (create your own course website)



- **Environmental Science Essential Study Partner CD-ROM.** A complete, interactive student study tool, this CD features animations, videos, and learning activities. From quizzes to interactive diagrams, you'll find that there has never been a better study partner to ensure the mastery of core concepts. Best of all, it's available FREE with a new textbook purchase in an optional package.

PACKAGING OPPORTUNITIES AND RELATED TITLES

McGraw-Hill offers many different packaging opportunities that not only provide your students with valuable environmental-related material, but also a substantial cost savings. Ask your McGraw-Hill sales representative for information on discounts and special ISBNs for ordering a package that contains one or more of the following:

Annual Edition: *Environment* 04/05

This 23rd edition is a compilation of current articles from the best of the public press. The selections explore the global environment, the world's population, energy, the biosphere, natural resources, and pollution.

Interactive World Issues CD-ROM

This CD explores environmental issues that affect various geographic regions. For example, you'll visit Oregon and investigate water rights of the Columbia River. Listen to Native Americans whose living depends on salmon fishing and then to the farmers who need water to irrigate their crops. Additional case studies discuss migration in Mexico, apartheid in South Africa, population issues in China, and farming in urban Chicago.

New!! *Exploring Environmental Science with* GIS

This short book provides exercises for students and instructors who are new to GIS, but are familiar with the Windows operating system. The exercises focus on improving analytical skills, understanding spatial relationships, and understanding the nature and structure of environmental data. Because the software used is distributed free of charge, this text is appropriate for courses and schools that are not yet ready to commit to the expense and time involved in acquiring other GIS packages.

Student Interactive CD-ROM

This CD is packaged complimentary with every new copy of Cunningham et al: *Environmental Science,* 8th edition. The CD-ROM features chapter-based quizzes, chapter-based text web exercises, student tutorial, animations and PowerPoints of all the images found in the textbook.

Taking Sides: *Clashing Views on Controversial Environmental Issues*, Revised 10th Edition

This represents the arguments of leading environmentalists, scientists, and policymakers. The issues reflect a variety of viewpoints and are staged as "pro" and "con" debates. Issues are organized around four core areas: general philosophical and political issues, the environment and technology, disposing of wastes, and the environment and the future.

Field and Laboratory Activities for Environmental Science, 7th Edition by Enger and Smith

The major objectives of this manual are to provide students with hands on experiences that are relevant, easy-to-understand and applicable to the student's life, presented in an interesting, informative format. Ranging from field and lab experiments to conducting social and personal assessments of the environmental impact of human activities, the manual presents something for everyone, regardless of the budget or facilities of each class. These labs are grouped by categories that can be used in conjunction with any introductory environmental textbook.

Sources: *Notable Selections in Environmental Studies*, 2nd Edition

This volume brings together primary source selections of enduring intellectual value—classic articles, book excerpts, and research studies—that have shaped environmental studies and our contemporary understanding of it. The book includes carefully edited selections for the works of the most distinguished environmental observers, past and present. Selections are organized topically

around the following major areas of study: energy, environmental degradation, population issues and the environment, human health and the environment, and environment and society.

Student Atlas of Environmental Issues by Allen

The Student Atlas of Environmental Issues is an invaluable pedagogical tool for exploring the human impact on the air, waters, biosphere, and land in every major world region. This informative resource provides a unique combination of maps and data helping students understand the dimensions of the world's environmental problems and the geographical basis of these problems.

You Can Make a Difference: Be Environmentally Responsible, 2nd Edition by Getis

This book is organized around the three parts of the biosphere: land, water, and air. Each section contains descriptions of the environmental problems associated with that part of the biosphere. Immediately following each problem or "challenge" are suggested ways that individuals can help solve or alleviate them. This book has been written to provide the reader with some easy and practical ways to protect the Earth and to help understand why the task is so important.

ACKNOWLEDGMENTS

We're indebted to all the students and teachers who have sent helpful suggestions, corrections, and recommendations for improving this book. Unfortunately, space doesn't permit inclusion of all the excellent ideas that were provided. All have been saved, however, and will be helpful in future editions. We hope that those who read this edition will offer their advice and insights as well. Little of the vast range of material in this book represents our own personal research. All of us owe a great debt to the many scholars whose work forms the basis of our understanding of environmental science. We stand on the shoulders of giants. If errors persist in spite of our best efforts to root them out, we accept responsibility and ask for your indulgence.

We want to express our appreciation to the entire McGraw-Hill book team for their wonderful work in putting together this edition. Kathy Loewenberg oversaw the developmental stages and has made many creative contributions to the book. Joyce Berendes, as production project manager, kept everything running smoothly and has been extremely tolerant and accommodating even when some of us have missed deadlines. Cathy Conroy did an excellent job of copyediting and spotting errors/inconsistencies. Connie Mueller and Lori Hancock found superb photographs. The folks at Precision Graphics did an excellent job of composition and page layout. Marge Kemp has continued to support this project over the years with enthusiasm and creative ideas.

We especially want to thank our distinguished panel of advisors who helped select this edition's cover, and more importantly, guided the amazing new art program through development. We're very grateful for their thoughtful and timely comments on such critical illustrations.

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We also gratefully acknowledge the constructive criticism of the many colleagues who provided reviews of this, and the previous, edition of the book. They include:

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